Effect of antitranspirants on growth and production of grain sorghum*[1/]

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COMPENDIO

Se llevaron a cabo experimentos de campo en la Universidad Agrícola Tamil Nadu, en Coimbatore, India, durante las estaciones de verano y de monzón de 1977, con sorgo de grano ('C S H 5') en condiciones de abastecimiento limitado de agua. Los resultados revelaron que los antitranspirantes aumentaron significativamente el número efectivo de hojas, el índice de área foliar (LAI) a la floración, y avanzaron el número de días hasta el 50 por ciento de la floración en 2 a 3 días. Los antitranspirantes también tuvieron una influencia significativa sobre el número de panículas emergidas por parcela, número de raquis por cabeza, tamaño de la cabeza, y peso de mil granos. Durante las últimas etapas del crecimiento del cultivo, los antitranspirantes tendieron a inducir las senescencia de las hojas más viejas. El rendimiento en grano aumentó en un 12 por ciento como promedio en la estación del monzón. La producción de materia seca también aumentó significativamente en un 8 por ciento sobre el testigo. Los antitranspirantes no tuvieron efecto adversos sobre la fotosíntesis. La aplicación a los 45 días después del sembrío fue la más eficaz.

Introduction

ENOUGH success has been achieved with antitranspirants as an approach to improve the internal water balance of the plants thereby increasing the dry matter production and grain yield. Antitranspirants have been reported to increase the total dry matter production (9, 11) and their effect on net photosynthetic rate was not detrimental (14). Fuehring (3) obtained a mean grain yield increase of 5 to 17 per cent with the application of phenyl mercuric acetate (PMA), atrazine and folicote (a film forming type), sprayed on grain sorghum at various times of under limited moisture supply. Over a five year period and under limited irrigation, Finkner *et al.* (2) found that foliar applied atrazine at 250 g/ha resulted in increase in yield of grain sorghum from 2.6 per cent to 11.3 per cent with an average of 6.2 per cent. Under dryland conditions, the yield increase ranged up to 25 per cent. The canopy sprays of kaolin resulted in an additional yield of 446 kg/ha or 11 per cent over the unsprayed control, averaged over three years (15). Hence it appears possible to increase the yield of dry sorghum with antitranspirants under limited water supply. This study was undertaken to investigate the effect of antitranspirants on grain sorghum.

Materials and methods

Field experiments were conducted at Tamil Nadu Agricultural University, Coimbatore, during the summer and monsoon seasons of 1977 under conditions of limited water supply to study the effect of antitranspirants on grain sorghum 'CSH 5'. The soil of the experimental fields was well drained sandy clay loam with low available N (142 kg/ha), medium available P (14.7 kg/ha) and high available K (197 kg/ha). The rainfall received in the summer season was 253.3 mm in 10 rainy days and during monsoon season it was 477.9 mm received in 25 rainy days. The average maximum and minimum temperatures were 34.51°C and 22.49°C during summer, and 31.93°C and 22.46°C during monsoon season.

Three factors *viz.* moisture levels, antitranspirants and times of application of antitranspirants were studied in split plot design with three replications. The treatment details are given in Table 1.

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Table 1.—*Treatment details.*

(a) *Main plots*

(i) Moisture levels - 2

M_1 - 2 irrigations at vegetative (30-35 days) and flowering (65-70 days) stages in addition to sowing irrigation

(ii) Time of application of antitranspirants - 3

T_1 - Aplication at 45 days

T_2 - Application at 60 days

T_3 - Application both at 45 and 60 days

(b) *Sub-plots* (Antitranspirants) - 4

A_1 - Control (Water spray)

A_2 - Atrazine as Gessaprim[1] at 250 g c.p/ha

A_3 - Kaolin[2] 6 per cent (W/V) suspension

A_4 - Power oil[3] (E-9267) 1 per cent (V/V) emulsion

Plot size:

Gross = 6.30 x 1.35 m; Net: 4.95 x 2.55 m

Spacing = 45 x 15 cm Fertilization = 90, 45, 45 kg N, P_2O_5 and K_2O/ha

	Summer	*Monsoon*
Date of sowing:	March 3, 77	July 25, 77
Date of harvest:	June 15, 77	Nov. 5, 77

Note: 1 Gessaprim, a commercial product, contains 50 per cent a.i. of atrazine.

2 Kaolin was supplied as Nekolin lumps by the Neyveli Lignite Corporation, Neyveli.

3 Power oil was supplied by Krishi Oil Corporation, Bangalore.

Plant height was measured at flowering (60 days). Number of effective leaves was counted at flowering and on 90th day. Leaf area index at flowering was computed as per the method of Stickler *et al* (16).

$$LAI = \frac{ML4 \times MW4 \times 0.747 \times N}{S}$$

Where:

LAI = Leaf area index

ML4 = Maximum length fourth leaf

MW4 = Maximum width fourth leaf

N = Number of effective leaves

S = Spacing in cm.

Yield attributes such as number of panicle per plot, length and breadth of the panicle, number of rachii per earhead and thousand grain weight were measured at maturity. Total dry matter production was determined by oven drying the above ground portion of the plant at 80°C and recording the weight. Grain yield was recorded at 14 per cent moisture and straw yield after sun drying the straw.

Results and discussion

The treatments failed to register a significant influence on growth and yield components due to the continued and unusual rainfall received after flowering in summer. Also, the rainfall received up to 45 days was meagre. Thereafter it was more or less uniformly distributed during the later stages of crop growth. Hence the available soil moisture was kept well above the critical level of 50 per cent and no moisture stress developed. As a result the summer crop behaved just like a bulk crop and the treatments had no effect on the crop. Hence the discussion is mainly oriented to the results obtained in the monsoon season.

Growth Components

The data on the effect of antitranspirants on growth components are presented in Table 2.

Plant height at flowering. High moisture level registered an increase in plant height (156.15 cm) at flowering compared to low moisture level (153.37 cm). Moisture stress in the early stage of growth might have reduced the plant height by shortening the internodes as reported by Robins and Domingo (13). There was no significant difference between different antiatranspirants and also between times of application.

Number of effective leaves at flowering. High moisture level registered a higher number of effective leaves (8.65) than low moisture level (8.29). Antitranspirants increased the number of effective leaves, the increment over control being highly significant. Water stress at an earlier stage might have induced the drought resistant mechanism of control plants to come into operation by hastening the leaf senescence (4). Antitranspirants reduced the evapotranspiration for about 15 days and increased the ASM* when applied during stress period. It resulted in better availability of water, thus alleviating the adverse effects of water deficit to a certain extent. Antitranspirants also increased the RWC* of leaves and maintained it for about 12 to 15 days after application, thereby controlling the internal water deficit also. Combination of these effects could have reduced the drought senescence and increased the number of effective leaves at flowering (8). Antitranspirants were particularly effective when applied at 45 days when stress conditions were beginning to develop.

Number of effective leaves at 90 days. High moisture level registered a significant reduction in number of effective leaves (6.23) when compared to low moisture level (6.43) due to better translocation of

Table 2.—Effect of antitranspirants on growth attributes - Monsoon 1977.

Treatments	Plant height cm	No of leaves		LAI flowering	Days to 50% flowering
		60th day	90th day		
Moisture levels					
1. Low	153.37	8.39	6.43	5.997	65.55
2. High	156.15	8.65	6.23	6.143	64.26
S.Ed	0.50	0.03	0.04	0.019	0.19
C.D	1.11	0.06	0.10	0.042	0.40
Time of applications of antitranspirants					
1 On 45th day	154.58	8.60	6.48	6.151	65.04
2 On 60th day	154.28	8.41	6.34	6.004	65.58
3. Both on 45th & 60th day	155.50	8.56	6.35	6.090	64.49
S.Ed	0.61	0.04	0.06	0.023	0.22
C.D	N.S	0.08	N.S	0.051	0.48
Antitranspirants					
Control	154.05	8.37	6.16	5.953	66.32
Atrazine	155.33	8.71	6.36	6.218	64.26
Kaolin	155.51	8.57	6.46	5.951	64.32
Power oil	154.15	8.64	6.35	6.152	65.26
S.Ed	0.91	0.05	0.09	0.044	0.24
C.D	N.S	0.11	N.S	0.088	0.49

nutrients from the leaves to the earhead, as a consequence of drying of lower leaves.

Neither antitranspirants nor the times of application of antitranspirants had significant influence at 90 th day. A comparison of this fact with the data on the number of effective leaves at 60 days is interesting. At 60 days both antitranspirants and the times of application showed highly significant differences in the number of effective leaves. Application of antitranspirants at 60 days resulted in lesser number of effective leaves on 90th day when compared to application at 45th day. This indicated that antitranspirants, when applied after boot leaf stage, tended to induce leaf senescence. It could be stated that antitranspirants have some physiological effect on senescense and translocation.

LAI at flowering. High moisture level recorded a higher LAI (6.143) than low moisture level (5.997), the increase being highly significant. The reduction in LAI under low moisture level may be attributed to the decreased cell size and intercellular volume caused by moisture stress (7). Antitranspirants increased the LAI and the increase was highly significant. Antitranspirants reduced the ET* and ASM considerably, thereby alleviating the soil water deficit to some extent. Also, they effectively controlled the internal water deficit through increased RWC and hence the leaf senescence did not occur. Application at 45 days was more effective than application at 60 days since the observation was made just on the day of application in the latter case.

Days to 50 per cent flowering. High moisture level advanced the 50 per cent flowering (64.26 days) compared to low moisture level (65.53 days) and this effect was highly significant. Sufficient leaf area is required to synthesize enough of the floral stimulus for floral initiation (12). As discussed earlier, more leaf area was available under high moisture level which would have provided sufficient floral initiating auxins for early flowering.

Atrazine caused the earliest flowering (64.24 days) followed by kaolin (64.32 days) and power oil emul-

* ASM = Available Soil Moisture; RWC = Relative Water Content; ET = Evapotranspiration.

sion (65.26 days). This earliness was significant over control (66.32 days). Antitranspirants reduced the ET, increased the ASM and RWC. All these mitigated the soil and plant water deficits. Hence, enough leaf area was developed to synthesize sufficient floral stimulus to allow initiation and this could be the reason for the advancement of 50 per cent flowering. Application at 45 days advanced the flowering since the application coincided with the peak vegetative stage.

Yield components

The data on effect of antitranspirants on yield components are presented in Table 3.

Number of panicles per plot. High moisture level recorded greater number of panicles per plot (164.4) than low moisture level (159.67). The lost growth during panicle initiation and development stages might have resulted in choking of earheads and hence less viable panicles. Antitranspirants increased the number of panicles per plot significantly. Obviously, antitranspirants provided a favourable environment for growth and development of the crop through increased ASM, RWC, number of effective leaves and LAI, which resulted in increased photosynthesis and production of panicles. Application at 45 days was more effective since stress symptoms were beginning to develop at that time and the crop was at its critical peak vegetative stage.

Length of the panicle. Greater earhead length was recorded in high moisture level and antitranspirant treated plots and it was significantly superior to low moisture level. Soil water stress during early stages of panicle development might have resulted in shorter panicles in low moisture level and control plots (1).

Breadth of the panicle. High moisture level and antitranspirants increased the breadth significantly. The reduction in breadth of earhead in control plots might be due to water stress 5 to 15 days prior to ear emergence which reduced the grain set per spikelet because of reduced assimilation (10). Antitranspirants reduced this stress effects during the most critical stage viz, boot leaf stage, thereby increasing the grain set per spikelet, which ultimately resulted in higher breadth of the earhead.

Table 3.—Yield components and yield - Monsoon 1977

Treatments	No. of panicles/ plot	Earhead length cm	Earhead breadth cm	No. of rachii	Thousand grain weight g	Dry Wt of dry matter g	Grain yield (kg/ha)	Straw yield (kg/ha)
Moisture levels								
1 Low	159.7	27.80	4.37	59.4	22.34	12681	3816	8728
2 High	164.4	29.15	1.53	60.0	22.29	12770	3847	8720
S Ed	0.7	0.24	0.04	0.5	0.26	211	178	95
C D	1.6	0.52	0.09	N.S.	N.S.	N.S.	N.S.	N.S.
Times of application of antitranspirants								
1 On 45th day	160.7	28.48	4.43	59.6	22.45	12842	3921	8857
2 On 60th day	158.5	28.15	4.43	59.5	22.05	12528	3712	8599
3 Both on 45th and 60th day	166.9	28.80	1.48	60.1	22.44	12794	4010	8720
S Ed	1.4	0.29	0.05	0.7	0.31	278	217	118
C D	3.1	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Antitranspirants								
1 Control	158.6	27.78	4.22	58.1	21.66	2009	3502	8766
2 Atrazine	165.6	29.06	4.62	60.4	23.03	13115	4164	8792
3 Kaolin	163.8	28.61	1.52	60.7	22.77	13013	4128	8792
4 Power oil	160.1	28.46	4.43	59.8	21.81	12889	3923	8612
S Ed	0.9	0.38	0.09	0.6	0.44	130	274	319
C D	1.9	0.78	N.S.	1.2	0.90	909	561	N.S.

Number of rachii per earhead. Antitranspirants had marked influence on the number of rachii per earhead. They increased the ASM by reducing the ET. They did not affect the root growth and uptake of nutrients (5). Dry matter production was increased by increasing the RWC and LAI. This, consequently, resulted in the production of higher number of rachii per earhead

Thousand grain weight. Antitranspirants had an appreciable influence on thousand grain weight and this effect was highly significant. The reduced test weight in control plants could be attributed to the adverse effect of moisture stress during pre-flowering stage. The increased test weight with antitranspirants was due to the increased supply of assimilates during the pre-flowering period because of increased ASM and greater amount of photosynthates

Total dry matter production (DMP)

Antitranspirants significantly increased the dry matter production. On an average the dry matter production was increased by about 8 per cent over control. Reduced DMP in control plots could be attributed to water stress at early stages which affected the photosynthesis directly by affecting various biochemical processes and indirectly by reducing the intake of CO_2 through stomata (7). The increased dry matter production due to antitranspirants could also be attributed to the favourable soil and plant water status in the treated plots. Sorghum fixes most of the CO_2 into C compounds such as malic and aspartic acids (6) and on several occasions fairly high rates of photosynthesis were obtained when stomata appeared to be closed since stomatal closure is not a satisfactory explanation for reduced photosynthesis (6). Hence, no adverse effect of antitranspirants on photosynthesis and DMP was observed.

Grain yield

Antitranspirants significantly increased the yield (Fig. 1). Atrazine (4164 kg/ha) and kaolin (4128 kg/ha) were on par with power oil (3923 kg/ha) but were significantly superior to control (3502 kg/ha). The increased yields due to applications of antitranspirants could be attributed to combination of several factors. As discussed earlier, antitranspirants increased the ASM during early stages, thereby eliminating the severe effects of soil moisture stress. They also increased the RWC, which in turn, controlled the internal water deficits. Treated plants had more LAI. Fifty per cent flowering was advanced which prolonged the reproduction phase, facilitating greater diversion of photosynthates to the earheads. Also later formed flowers were affected by heavy rainfall and this resulted in poor setting of grains in control plots. Antitranspirants also favourably influenced the yield components. They had increased the number of panicles per plot. Also, earhead size has been increased which probably resulted in increased grain number per earhead. Alleviation of moisture stress with antitranspirants increased the production of assimilates during pre-flowering period and resulted in better development of the panicles. During later stages, antitranspirants accelerated the senescence of leaves. As a result the stored assimilates in the senescing leaves might have been translocated to the earheads. The cumulative effect of all these factors might have resulted in significant increase in grain yield and the average increase was about 12 per cent over control.

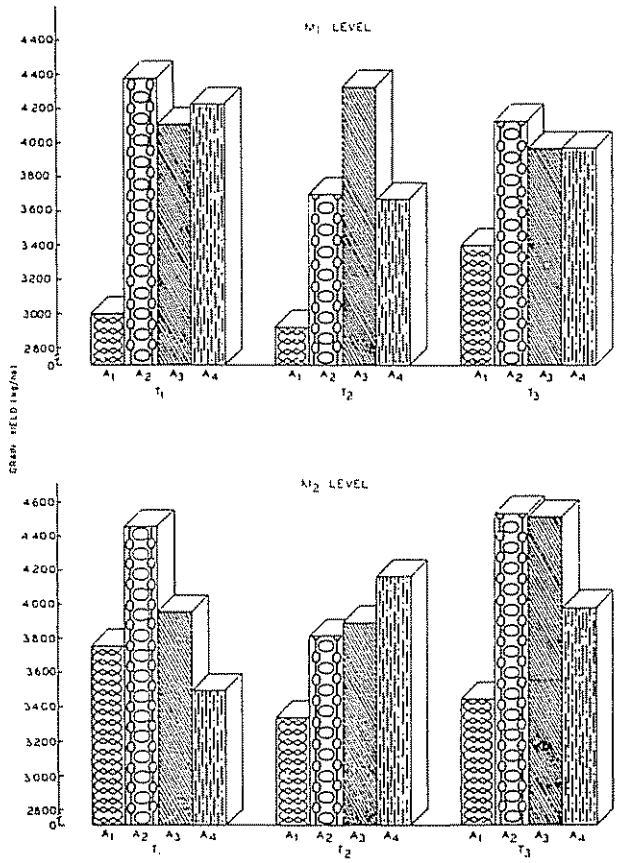

Fig. 1—*Grain yied in the monsoon season.*

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Summary

Field experiments were conducted at Tamil Nadu Agricultural University, Coimbatore, India during the summer and monsoon seasons of 1977 on grain sorghum (CSH 5) under the conditions of limited water supply. The results revealed that antitranspirants significantly increased the number of effective leaves, LAI

at flowering and advanceds the days to fifty per cent flowering by 2 to 3 days. Antitranspirants also had significant influence on number of panicles emerged per plot, number of rachii per earhead, size of the earhead and thousand grain weight. During later stages of crop growth, antitranspirants tended to induce the senescence of older leaves. Grain yield was increased by 12 per cent on an average in the monsoon season. Dry matter production was also increased significantly by about 8 per cent over control. Antitranspirants had no adverse effects on photosynthesis. Application at 45 days after sowing was most effective.

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Notas y Comentarios

El polen en el estudio de los insectos

Las imágenes del microscopio electrónico de barredura siguen abriendo fronteras a la investigación científica. La claridad en los grandes aumentos de los detalles facilita la clasificación y comparación de estructuras microscópicas, con una seguridad no disponible antes.

Tres científicos de Winnipeg, Canadá, W.J. Turnock, J. Chong y B. Luit, han desarrollado un método inmediato para identificar cuáles cultivos son visitados por unos noctuidos mediante micrografías del microscopio de barredura. Muchas especies de estos lepidópteros causan daños severos a las plantas cortándolas al nivel del suelo *(Canadian Journal of Zoology,* vol. 56, p. 2050).

Mariposas de *Marmestra configurata,* criadas en el laboratorio, se pusieron por una noche en jaulas con plantas de nabo en floración, y mariposas ferales se colectaron individualmente de una pared en un barrio de Winnipeg, adonde habían sido atraídas por rayos ultravioleta. Después de mirar con un microscopio a las proboscis de los insectos para ver si llevaban polen, se pegaba la cabeza del insecto en una plaquita de aluminio. Estas cabezas montadas se cubrieron, en el vacío, con una capa de oro de 80 nanometros de espesor, y las muestras se examinaron con un microscopio electrónico de barredura.

La observación mostró que una probosis de *Fischia discors* tenía adheridos granos de polen de una especie de compuestas y así para todos los casos. Se dedujo, de esta manera, cuáles plantas habían visitado las polillas antes de ser capturadas.

Este método será aún más útil cuando estén disponibles buenos atlas de granos de polen vistos por el microscopio electrónico de barredura.